2. Subject development

As far back as 1933, Soviet scientists were beginning to show interest in the effects of electromagnetic fields (EMF's) on the central nervous system (CNS) of both humans and animals. In a 1957 review article, Livshits [1] cited no fewer than 28 Soviet publications on this subject which had appeared by the end of the 'thirties. Even therapeutists were actively concerned with the effects of UHF therapy on the human central nervous system. Turlygin's account [2] in 1937 was one of the first of its kind to report on the effects of a microwave-range field on human central nervous system excitability. Using a very crude generator, he observed a 200% increase in the sensitivity of the CNS of a patient under his care.

During World War II there was an understandable lull in research devoted to the neural effects of EMF's which, surprisingly enough, continued into the mid-1950's. Then, after the publication of two large review articles by Livshits in 1957 and 1958 [1,3], an increasing number of Soviet articles on this subject began to appear.

By 1957 [1], the Soviet approach to research on the neural effects of EMF's was broken down by Livshits into the following categories: 1) comparison of the effects of EMF's on denervated and intact organs; 2) the use of neurotropic drugs or stimulants to amplify the neural effect of EMF's; and 3) comparison of the effects of EMF's with the effects of extensively investigated stimuli such as heat and cold to demonstrate a specific mechanism of EMF effects. This same basic approach is still true of the Soviet effort in this area. However, as the research, development, and production of EMF-generating equipment has intensified, so has concern for the medical condition of personnel working in the vicinity of various EMF sources such as klystron and tube generators. As this report will demonstrate, medical doctors and hygienists have become increasingly concerned with the nonthermal, or so-called "specific" effects of low-intensity (less than 10 mw/cm^2), microwave-range EMF's. Since Livshit's two review articles, Soviet interest in the neural mechanisms of EMF effects has increased dramatically, research approaches have been refined as a result of radioelectronic developments, and a large Soviet community representing a multitude of disciplines is now devoted to the theoretical and practical aspects of the effects of EMF's on neural structures and functions.

2. US Embassy (Moscow)
Employee bio-damage
(thermal and athermal)
Hazard at: **0.1 - 15μW/cm2**
(Source: X-rayed Without
Consent; Bert Dumpé; 1989
per Dept. of State records)

4
VDT STUDIES—UNITED STATES AND CANADA

Many investigations have been conducted to determine the cause of VDT user trauma. Studies in at least six countries were original (the United States, Canada, Spain, Norway, Sweden, and Finland). The conclusions in the other several hundred investigations were essentially based on hearsay. Nevertheless VDT experts refer to the overall work as "scientific data."

The National Institute of Occupational Safety and Health, which monitors the welfare of people in offices, examined at least 19 computerized workplaces since 1975. To date, the agency's conclusions have not deviated from their first opinions in which NIOSH stated:

1. VDTs are harmless.
2. Emissions are too low to measure, and are therefore well within human tolerance.
3. User complaints are imaginary.
4. Stress is due to poor posture and job dissatisfaction.
5. An ergonomically treated environment will eliminate user complaints.
6. Concern is unwarranted.

Despite the assurances of NIOSH and other responsible parties, VDT user complaints persist and escalate. The maladies people describe resemble those associated with radiation sickness. Physicians have not recognized this.

The work of American and Canadian investigators is summarized in this chapter. Some conclusions were referenced by experts at the 1981 and 1984 congressional VDT hearings. Most studies reported here and in chapter 6 were overlooked.

4-1 NONIONIZING RADIATION

One of the earliest indications scientists and physicians had that nonionizing radiation induces biological damage was in the American Embassy in Moscow. Since 1953 the embassy was the target of microwave illumination from a Soviet transmitter. Employees developed unusual symptoms and diseases; some died. The Department of State (DOS) requested a facility and medical investigation.

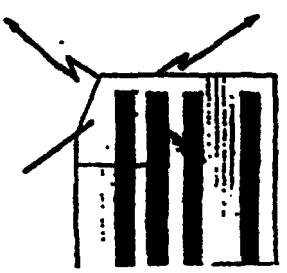
DOS FACILITY

The National Telecommunications and Information Administration (NTIA) responded to the DOS by commissioning Johns Hopkins University to perform a facility study. The Applied Physics Laboratory (APL), a division of the university, analyzed microwave measurements taken by DOS personnel over a 25-year period. A summary of the evaluation follows.

The 10-story embassy building was the target of illumination from a Soviet microwave transmitter for 25 years. Throughout the period, the distance of the radiation source was approximately 100 meters west, east, and south of the building.

The illumination of the Chancery is divided into two periods. The first 22 years (1953 to May 26, 1975) was given the code name TUMS. The second period (May 28, 1975 to February 1977), MUTS, was divided into two phases: MUTS-1 and MUTS-2.

TUMS. During this period there was a single source of illumination. The microwave beam radiated from a Soviet apartment house about 100 meters west of the Chancery. The highest radiation levels measured were within 2 feet of doors and windows on the west wall. The average maximum exposure was 5 microwatts per square centimeter.



MUTS-1. Microwave energy was high for 8 months. Beams were directed from the east and south. The average maximum exposure was 15 microwatts per square centimeter.

During part of MUTS-1 (July 1975 to January 1976), microwave transmission originated from two sources: (1) the roof of an apartment building 80 meters east of the Chancery, and (2) an office building nearly 80 meters south. The east facade of the Chancery had many windows. The south had windows in rooms 901 and 1001, and the stairway on the 8th and 9th floors.

From 24 to 31 July 1975, room 901 had an average radiation level of 9.0 microwatts per square centimeter throughout the area. Microwaves were focused sharply on the upper floors. The highest radiation levels recorded were in offices in the east side at the center of the building. The intensities increased toward the southeast rooftop corner, above room 1001.

The highest reading inside the building during MUTS-1 was within 2 feet of the window in room 1001. The signal strength on the rooftop on January 24, 1976 was recorded at 24 microwatts per square centimeter.

MUTS-2. Around November 1975 the energy of the Soviet transmitter, on the rooftop of the apartment building (100 meters east), suddenly dropped to 2 microwatts per square centimeter. Screens were installed on windows on February 6, 1976. The lowest energy was recorded from this date through February 1, 1977.

The microwave signal, transmitted from the south and east, produced an average maximum exposure that measured a fraction of a microwatt (less than 0.1 microwatt per square centimeter).

There was an area (region 2) where the reading was only 0.75 microwatt per square centimeter. Single individuals in the south wing were exposed to less than 0.1 microwatt per square centimeter.

In the subsequent biological study performed by Lilienfeld, the people exposed to fractions of a microwatt were grouped among the unexposed. Those working in shielded areas were also placed in that category. This is tantamount to saying that osteogenesis equipment does not affect bone tissue because its energy is too low.

Conclusion. As complete a model as possible was developed from the data recorded by DOS personnel. Matter is known to absorb microwave energy (as in microwave cooking). However the incidence of disease (morbidity) and mortality, reported by Embassy employees, cannot be attributed to the low levels of microwaves passing through the building.

There is a need for authoritative biophysical analysis of the microwave field illuminating the Embassy. At this time, it is only possible to consider theoretical biological effects from the low frequency microwave radiation beamed at the Chancery. Additional studies are recommended.

The degree of biological damage in DOS personnel would depend on dose, time, and distance. The Soviet transmitter was consistently at a distance 80 to 100 meters from each wall of the Chancery. Dose and time varied. Microwaves were strongest at the rooftop and above doors and windows which are usually framed with metal, a highly conductive material.

The APL and associated experts indicated that microwaves are "opaque to masonry walls; radiation enters through door and window openings." This may be so, but radiation can perform its work indirectly by energizing matter. This was confirmed by Russell H Morgan, professor of radiology at Johns Hopkins University and Hospital (1961). Dr Morgan, who identified the natural radioactive materials in humans and the environment, said:

> Among the radioactive elements in rocks and soil is uranium, thorium, and their decay products; and potassium. The concentration varies throughout the earth. Because rock is frequently used as a building material, masonry is an important source of radiation to which humans may be exposed.
>
> The radiation from natural sources is essentially gamma (approximately 50 mR per year), which is penetrating. Radon and thoron diffuse from the earth and building materials. Carbon, calcium, potassium, and iodine are natural constituents of the body's soft tissues and fluids. (The elements are found in the earth and in rock.)

Illumination of the Chancery's building materials must have elevated the temperature of, and increased chemical reactions in, radioactive matter in walls of the building. The secondary energy was transmitted to people. It energized elements in the body, which caused biological reactions as if their tissues were "seeing" the energy source. The more radioactive materials in the walls the greater will be the biological distress, even when the energy of the irradiation source is low.

The Soviet transmitter had three microwave intensities: medium, high, low (Table 4–1). The severity of biological damage in DOS personnel should correspond to the exposure phase, and correlate with the death rate, in the 23–year period (1953–1976). The temperature in the west, south, and east sides of the building would also influence biological perturbance.

Table 4-1 Quality and Effect of DOS Facility Energy

Exposure Phase	Microwave Intensity	Average Maximum Microwatts	Expected Biosystem Reaction
1. TUMS	Medium	5.0	Moderate, bothersome, and inexorable tissue damage.
2. MUTS-1	High	10.2	Immediate and severe damage.
3. MUTS-2	Low	0.1 to 2.0	Mild, subtle, but inexorable perturbance.

Deaths *	Males	Females
1953-1960	37	3
1961-1966	4	1
1967-1971	3	5
1972-1976	2	2
	36	11

* Due to insufficient data, 13 deaths were excluded from the statistics. The victims were all males.

A change in blood quality alone should have been indicative that something was wrong with the Embassy's environment. Lilienfeld examined diastolic blood pressure, and found that DOS personnel had a higher rate after their tour. They also had fewer white blood cells, and more psychiatric problems, than the comparison group. Experts declared that these, and other disorders were due to chance.

DOS Biological Study

Together with a team of individuals, whose expertise ranged from nursing to engineering, Dr Abraham Lilienfeld of Johns Hopkins University analyzed many health records of personnel stationed at the Embassy during the illumination period. The data was compiled with an IBM 370/148 computer. It consumed 200,000 punch cards in the initial evaluation of personnel records, and 2 to 3 times as many in the editing process.

Besides DOS employees, individuals at the post included people from the United States Information Agency, the Departments of Defense and

Agriculture, and the military. For the purpose of this discussion, all agencies at the embassy will be referred to as DOS personnel.

Lilienfeld compared the maladies of DOS personnel to those reported at other embassies (the comparison group). His team analyzed statistics of mortality and disease (morbidity) in male and female employees, and dependents (spouses and children). Generally the team found: (1) more deaths among the male population than the female; (2) a high rate of cancer in females; and (3) a high incidence of mumps, and leukemia and other blood disorders among children.

It is possible that DOS children did not actually have mumps, but swollen glands (salivary) of the tongue, throat, and ears. An unexplained outbreak of mumps was reported among schoolchildren in the District of Columbia, Maryland, Illinois, Kentucky, and other states (1988). The glands of VDT users swell. The condition may be diagnosed as mumps.

Personnel at the embassy sensed biological perturbance, which they suspected was caused by some abnormality in their environment; radiation. They measured and monitored the diabolical agent which vibrated at various frequencies, including television and FM radio bands. Microwaves were streaming through the Chancery as they do in a microwave communications tower. No one believed or acknowledged that radiation caused the morbidity and mortality occurring at the Embassy.

In research germane to the problem at the Moscow Embassy Swedish neurologist at the University of Goteborg, Dr Hans-Arne Hansson (1985), found that electromagnetic radiation affects radar and microwave workers.

> Radar workers suffered brain damage, altered spinal fluid, frontal lobe disorder, memory loss, and other neural injury. A protein, part of the white matter (glial cells) that insulates nerves of the brain, was discovered in cerebrospinal fluid of radar and microwave workers. As a result of altered proteins and retinal damage, two radar workers became partially blind.
>
> Exposure of nervous tissue to electromagnetic fields, ranging from power line to microwave emissions, may cause a wide range of biological effects. The disorders may remain silent for a period that lasts months or years. People exposed to microwaves could be at risk of sustaining brain damage. (Sally Squires, Washington Post 1985.)

Samples of spinal fluid were taken from DOS personnel, but they were not scrutinized as closely as the Hansson experiments (Koslov 1985). Had the assays been carefully studied, the Lilienfeld team might have found abnormal protein concentrations in the cerebrospinal fluid of DOS personnel. If they were using VDTs, the assays of the comparison group would have been similar. VDTs and television receivers emit microwaves like those flowing through the embassy. The radiation is not as energetic because CRT frequencies are lower. Since biological injury is cumulative, the result of high and low energy stimulation will be the same.

In the United States, Sweden, and Russia researchers observed that tissues heat when workers get too close to microwave antennas. Despite reports of adverse health effects from low level microwave energy published by Poland in 1976, the APL and Lilienfeld concluded that radiation permeating the Embassy was tolerable. A summary of Lilienfeld's investigation follows.

> The medical histories of over 22,000 people, alive and dead, were reviewed. There were 4,800 people at the Embassy between 1953 and 1976; 1,800 employees and 3,000 dependents. The comparison group consisted of 7,500 people; 2,500 employees from 9 posts in Eastern Europe and 5,000 dependents.
>
> Obviously, the most important health effect in a population is reduced longevity or early death. There were 194 deaths recorded in the studied population; 152 males and 42 females.

Since data was incomplete, the 194 figure excludes 13 male deaths from the statistics. At least 47 of the 194 deaths occurred between 1953 and 1976. This means that 147 people died during the study period (1976 to 1978). The insult (injury) that caused the result (death) may have transpired during MUTS–1 when high energy was beamed from two sources.

> The number of deaths in the male population (excluding the 13) is 50 percent of the expected mortality of the United States. No differences were observed between the Moscow and comparison group. There is no satisfactory explanation for the 42 female deaths; 80 percent of the United States population.
>
> The morbidity in the Moscow and comparison group was nearly equal. Many health problems were observed; some were serious. Only two

differences were conspicuous in the two groups: (1) the Moscow male employees had a threefold higher risk of acquiring protozoal infections, and (2) men and women in the Moscow group had slightly higher incidents of the most common health conditions reported. (According to Alexander (1965), item 2 is a telltale sign that the experimentals were poisoned by radiation.)

The health conditions of DOS personnel cannot be related to microwave exposure. No consistent pattern of increased morbidity is evident in the group exposed to other than background (natural) microwave radiation. (Individuals exposed to less than 0.1 microwatt were classified among the unexposed. Therefore ailments in this group, attributed to background, may have occurred during MUTS–2.)

Men and women in the Moscow group reported more visual problems than the comparison group. Most were due to correctable refractive errors. The men had more psoriasis; the women more anemia. (Women naturally have a lower blood volume than men.) Men reported a high incidence of depression, irritability, and memory loss. (Alexander stated that depression, and other mental perturbance, indicates that radiation has affected cranial organs.)

In view of the published articles 'that the health of Embassy personnel was in danger,' it is not surprising that the Moscow group had a higher rate of morbidity than the comparison posts. (What about the dead and extremely ill people; how were they influenced by media reports?) No relationship was found between the occurrence of health symptoms and microwave exposure.

The children studied experienced many health problems. The maladies were similar in the Moscow and comparison groups. There was one notable difference, mumps occurred twice as often in Moscow than in the comparison group. (Radiation stimulates the glands which shrink, swell, or become infected.)

Conclusion. No convincing evidence was discovered that would directly implicate the low levels of microwave radiation, beamed at the American Embassy in Moscow, as the cause of any adverse health effects, as of the time of this analysis.

Recommendations. The results of this study could be interpreted that microwave radiation at the Moscow Embassy did not produce any deleterious health effects. It should be made clear that generalizations must be made with caution. The group with the highest exposure should be analyzed at intervals of 2- to 3-year periods. A surveillance system for deaths and malignancies should also be established.

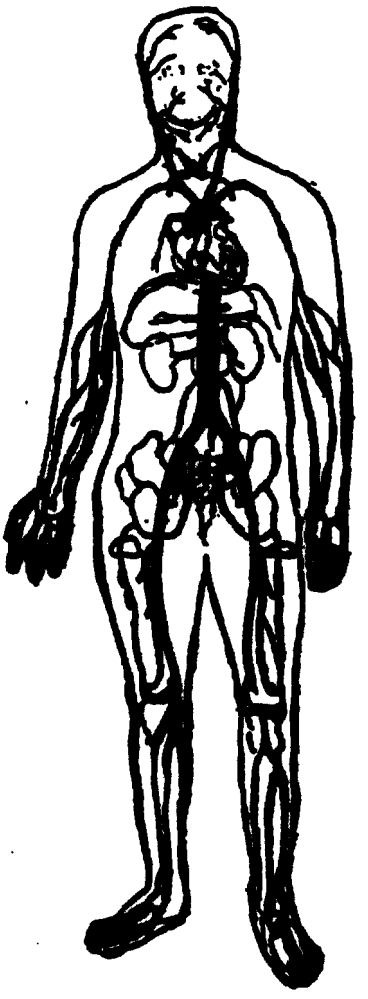
Table 4–2 lists some of the symptoms and diseases recorded. The population (N), which equals 879 DOS and 1,303 comparison, had similar maladies because the body can get sick in only so many ways. Lilienfeld noted that the incidence of eye problems, anemia, and ulcers approached

Table 4-2 DOS Personnel Mortality and Morbidity

Morbidity	Personnel in Population: DOS Personnel (N=879)	Personnel in Population: Comparison Group (N=1,303)
Sensory		
Eye trouble	319	478
Glasses	552	875
Ear, nose, throat, running ears	505	816
Sinusitis, require hearing aid	164	287
Skin, boils and disease	268	405
Cardiovascular		
Chest pain, palpitations	219	349
Anemia	6	5
High/low blood pressure	108	178
Gastrointestinal		
Appendicitis	130	216
Diabetes	7	9
Jaundice, hepatitis	96	165
Kidney stone, blood in urine, frequent and painful urination	126	189
Bloody stools, piles, dysentery	333	501
Abdominal trouble, gallbladder, digestive disorders	323	510
Nervous System		
Dizziness	37	75
Epilepsy	2	5
Headaches	74	131
Nervous problems, neuritis, stutter	78	144
Paralysis	9	27
Respiratory System		
Scarlet fever	119	182
Tuberculosis	40	77
Asthma	65	84
Chronic colds, cough, spit blood	128	192
Whooping cough	417	632
Musculoskeletal System		
Back and bone pain	143	1206
Foot trouble, leg cramps, loss of limb, swollen feet	222	332
Lameness	21	43
Glandular		
Thyroid/goiter	5	12
Mumps	597	878
Joints		
Arthritis/rheumatism	85	159
Swollen joints	75	99
Other		
Tumor/cancer	205	281
Venereal disease	57	46
Rupture	87	143
Weight change	165	246
Dental problem	102	153
Insomnia, sleep walking, nightmares	74	97
Emotional Distress		
Attempted suicide	1	3
Depression	30	56

Defects in Children Born After First Tour	Percentage Offspring: DOS Personnel (N=327)	Percentage Offspring: Comparison Group (N=428)
Spina bifida	1.0	1.0
Eye	0.0	1.0
Heart, and circulatory	0.0	2.0
Nervous system	1.0	1.0
Genital organs	1.0	1.0
Musculoskeletal	1.0	2.0
Urinary system	0.0	1.0
Cleft lip and palate	0.0	1.0
Clubfoot, other limbs	2.0	4.0

Compiled from: Abraham M Lilienfeld et al, "Foreign Service Status Study," *Final Report*, The Johns Hopkins University, July 31, 1978, pp 117-120, 232.



Trauma is systemic in adults, children, and the unborn

statistical significance in DOS personnel. Although not shown, male morbidity was usually between 25 to 65 percent higher than female. Taking into account that radiation always aggravates existing disorders, the data compiled for "diseases or conditions ever present" is used in this listing.

Since data was lacking, Lilienfeld's team did not correlate the maladies with the three illumination phases. This information, and the location of DOS personnel within the Embassy in relation to the microwave transmitter, is imperative to perform a thorough study. Location and period of irradiation would partly explain the variability of personnel maladies, and the death rate which probably climaxed during MUTS–1.

Between the late 1960s and early 1970s workers in various ecosystems worldwide used VDTs; a television receiver attached to a keyboard. For instance in the United States (1976), court reporters worked with a Beehive terminal (CPU) wedded to a black and white television set. Some workers complained that their "head and face felt numb." DOS and comparison group personnel may have been using similar configurations.

Lilienfeld's statistics (Table 4–2) suggest that health problems at the Embassy were no worse than maladies of the comparison group. He was alarmed by the mumps outbreak and other morbidity in children, who presumably did not use computers. The team did not qualify its information. How old were the people afflicted with mumps; below or above age 9? What caused the birth defects and problem pregnancies occurring at the Embassy after the employees' first tour of duty? The birth defects in offspring of controls and experimentals were almost equal; why? Fatigue, mental confusion, anxiety, and most disorders reported to Lilienfeld were observed by NIOSH in the San Francisco survey, and by NASA in the astronauts. The common element to which they were exposed was radiation.

The DOS facility and biological studies, like most, are inconclusive. The APL investigation concentrated on microwave measurements. There is no indication that either team analyzed other exposure (eg, VDT) DOS personnel may have had. If people, especially those in the southeast corner (rooms 901 and 1001), were using VDTs visual and other disorders would have been severe during any phase of irradiation. VDT users in the comparison group would have had similar problems.

A group of experts from the Electromagnetic Radiation Management Advisory Council (ERMAC) assessed the radiation bombarding the Moscow Embassy, and the biological trauma reported by DOS personnel. Their consensus was the same as that of the APL and Lilienfeld teams.

ERMAC Analysis

In 1980 the ERMAC met to assess the biological implications of the microwave environment in Moscow. Members of the group included experts from universities, hospitals, and private companies. The consultants were employed by General Electric, the University of Washington, the Virginia Commonwealth University, NTIA, APL, George Washington University, the University of California, Bell Laboratories, Gerry L Pettis Memorial Veterans Hospital, Argonne National Laboratories, and the universities of Miami and Tulsa; one consultant was an independent engineer. The ERMAC experts concluded:

> **The models used for the analysis of biological hazards are overstated. Other electromagnetic radiation is more intense than that impinging on the Embassy. There is no scientific evidence, or theoretical grounds, to suggest that biological disorders reported by Embassy personnel were due to microwave irradiation.**

And so the effects of microwave radiation in Moscow ended on the same note as VDT studies: There is no evidence that low level nonionizing radiation causes tissue damage; biological perturbance is due to chance. It appears that neither the APL, Lilienfeld, nor ERMAC endeavored to find a common factor. So it is in the VDT environment, and investigations of alleged injury from the emissions of high voltage power lines.

BIOLOGICAL INTERFERENCE

The potential of the biosystem changes when organisms absorb excessive natural or artificial electricity. Galvani and other scientists discovered that electric current causes friction as it travels through tissues and associated chemicals. Spasms in the nerves and muscles, and chemical change are the visible reactions to energy absorption. An elevated biological charge is the invisible effect. However it is perceptually apparent

in that individuals or organisms gain weight, become hyperactive, and dart about like ignited firecrackers.

Charged tissues vibrate at high frequencies. Ions rushing through them to ground create a sort of "ionic wind" (conduction current). The added energy causes chill inside and outside the body. VDT users experience these sensations which were observed in other organisms. Workers use heaters to ward off chill. Heat causes fast chemical reactions that exacerbate their perturbance. Bridges and Preache analyzed data that showed change in organisms exposed to electromagnetic radiation.

Power Line Radiation

In 1979 Jack E Bridges and Maurline Preache reviewed literature on the biological effects of electric fields from high voltage power lines; excerpts follow.

> **Electric fields induce the same current in the body as household appliances. Therefore the electric field of power lines is only a subset of the usual 50 and 60 Hz electromagnetic environment of industrialized communities.**

Depending on the distance it must travel and other factors, a power line carries 10,000 to over 500,000 volts. Its energy is stepped down to 120 or 220 volts, which vibrates at a frequency of 50 or 60 Hz. If 120 volts can electrocute humans, 10,000 volts dissipating from power lines must have some biological effect.

> **Most investigators used fish and other organisms as test subjects. The reactions of animals cannot be compared to those of humans. For that reason, it is not yet understood how electric and magnetic fields induce currents and electrical potentials in humans and animals. (Energy flows in humans as it does in any electrical and electronic circuit.)**
>
> **The electromagnetic fields of power lines produce small arc discharges, air ions, low level acoustics, and radio noise. These phenomena are confined to the immediate area within 100 feet of power lines. The electromagnetic fields charge the skin, causing electric current to flow within humans, and through the body to ground.**

3. US Embassy (Moscow)
Hazard at: 1μW/cm2
Result: Illness and death

ASSESSMENT OF HEALTH HAZARD AND STANDARD PROMULGATION IN CHINA

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Microwave Institute
Chekiang Medical College
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In general, radiofrequency and microwave radiation at sufficient levels of intensity and duration of exposure could cause harmful effects on a living organism, but the bioeffects and their mechanism are not yet well known. There are many uncertainties and differences of opinions, so that the safe exposure limits proposed in various countries differ from each other greatly, and there are two different types of safe exposure standards to consider depending on the population to be protected. There is an occupational standard which is used to protect persons working in the RF or MW environment, and an environmental standard to protect the general public. The safe exposure level of the latter is often as low as one tenth of the former, because the general population includes children, pregnant women, and individuals with various diseases. Both of these exposure standards differ from the emission or performance standards which restrict the emission of radiation from devices, such as the emission standards for microwave ovens in the United States and Canada. An exposure standard refers to the maximum permissible exposure level to the body, which must be based mainly on realistic assessment of health hazard, and which is to be discussed here.

Setting of the standards is not a simple task. It is necessary to establish a quantitative relationship between power densities of incident radiation and all biological effects for human beings. Quantification of the biological response to microwaves is a complex problem because of the wide range of the frequency spectrum. There are a large number of physical and biological variables and complex interrelationships among these variables. Most of the scientific data has been obtained from experiments on small animals or simpler organisms, and extrap-

olating laboratory results to man is not a clearly defined process. Additionally, there is a large amount of uncorroborated and controversial evidence of various biological effects. In these cases, the assessment of health hazard for "Standard" promulgation should rely mainly on the health status of personnel professionally exposed to RF and MW, although the information available in this field is limited. In various radiation conditions of human exposure, since it is impossible to make quantitation precisely and distinction between various radiation conditions strictly, the results of experiments with animals on bioeffects of RF and MW should be supplemented to the human exposure data.

Assessment of Health Status of RF and MW Workers

Some cases of acute reaction to microwave overexposure have been encountered [1]. The syndrome seems to consist mainly of subjective complaints of headaches, nausea, vertigo, and sleeplessness. Objectively, hypertonia, changes in cardiac rhythm, and a skin rash may be encountered. EEG examination may show a decrease in amplitude of alpha waves. In all cases the symptoms were transient and disappeared completely after a few days of sedation and rest. In one case, noted by the present author, the patient was extremely excited, highly unsteady in body temperature and heart rate, and evidenced reversible impairment of visual acuity and ventricular block. The symptoms lasted several weeks, even months. In general, the power density of microwave exposure causing acute reaction must be above at least 30 mW/cm^2. There is no doubt that the maximum permissible exposure level should be far below that level.

In setting a standard, one of the most important considerations has to be chronic exposure. As the assessment of the relationship between exposure levels and the health status of personnel professionally exposed to RF and MW is difficult, large groups must be observed in order to obtain epidemiological data with statistical significance. Many contributions in this field have been made by Soviet authors. Papers have also been published by authors from Czechoslovakia, Poland, USA, Sweden and so forth. In recent years, some investigations have been carried out in China. A large part of these findings concerning health hazard will be discussed here jointly.

The first topic is quantitation of human exposure. In view of the lack of personal dosimeters, the quantitation of exposure during work is extremely difficult, particularly where the personnel move around in the course of their duties and are exposed to moving beams or antenna of radars. Additionally, it is impossible to evaluate the exposure over a period of several years. So on the basis of analysis of working conditions, authors usually roughly divide the

personnel examined into two or three groups named high, (middle), and low power density groups. In fact, the exposure levels generally range from some tens to several hundred uW/cm^2 for professional microwave workers. One or two hundred uW/cm^2 as the demarcation line between high and low power densities has been adopted by some researchers. Only in a few working places do the microwave exposure levels exceed 1 mW/cm^2 or 10 mW/cm^2.

The principal part of the clinical findings from observed microwave workers is similar in different countries. Symptoms of functional disturbance in the central and vegetative nervous systems are the main manifestation. These will be described in the following with the results of investigations in China being compared with those in other countries. The investigation [2] on which the "Chinese Tentative Standard" is mainly based was conducted in 11 factories and institutes. The microwave workers observed had worked with microwave equipment (most of them were PW in cm range) more than one year, and a large part of them had 5 - 15 years of working experience. Everyone in the study had been in an ordinary work setting for the last three months. There were 841 workers given clinical observation, with 471 persons observed as a control group, their sex and age distribution similar to that of the microwave workers. The microwave workers were divided into two groups in terms of power density exposed. The first group, 306 workers, was exposed to a higher power density of >200 uW/cm^2 and the second group of 535 workers, to a lower <200 uW/cm^2. There was no significant difference in ages and working experience of these two groups ($p<0.05$).

1. Effects on the Nervous System

The results confirm the previous findings of Soviet authors on the occurrence of subjective complaints (Table 1). Another finding in the microwave workers was the partial loss of hair. The most pronounced symptoms were headache, fatigue, disturbance of sleep (insomnia or somnolence) and decrease in memory. The persons who complained of any of the three symptoms mentioned above were defined as "neurasthenia" and the incidence of neurasthenia is shown in Table 2. It is indicated that there were significant differences between any two groups.

A part of the observed persons (106 in all) were examined for EEG. The microwave workers' EEG revealed an increase in theta and delta waves, but there were no significant differences in statistics.

Similar complaints and incidences of neurasthenia symptoms were observed in RF workers in China, and the places where they worked were at the field strengths of several hundred V/m.

TABLE 1 Complaints of Microwave Workers (%)

Authors	No. of workers	Headache	Fatigue	Sleep disturbances		Memory decrease	Irritability	Hyperhidrosis	Abnormal menstruation
				Sleepless	Sleepiness				
Present authors (1979)	841	44-44.8	38-40.5	25.5-26	11-11.1	46.4-50	14.4-19	12.1-18	14.6-20
Sadcikova (1974)	1180	44-45	47-57		11-14	10-22	28-38	32-58	
Ramzen-Evaokinov (1970)	155	44	29	35			36	25	
Tjagin (1966)	573	33.5	46.2	25.3			9.6	25.5	
Uspenskaja (1963)	100	37	31	29			9	7	
CONTROL									
Present Authors	471	27.6	14.4	18.3	4.3	17.2	9.6	6.6	6.6
Sadcikova	200	12	7		2	1	6	12	
Ramzen-Evdokinov	50	7	8	3				4	
Tjagin	184	10.8	5.9	8.7				2.7	
Uspenskaja	100	15	22	2				4	

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2. Effects

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TABLE 2: Incidence of Neurasthenia Symptoms

Group	Incidence (%)	Groups for X^2	p
1	32	among all	<0.001
2	24.1	high to lower	<0.02
3	11	lower to control	<0.001

2. Effects on the Cardiovascular System

The microwave workers who complained chiefly of palpitation and pains around the cardiac region were in the high power density microwave radiation group; the incidences were much higher than for the control group ($p<0.001$). The incidences of hypotonia ($\leq$100 mm Hg) were higher in the microwave groups (high and lower density group in 25.5% and 22.6% respectively) than in the control group (15.3%). Reviewing the reports [3,4,5] published by Soviet authors, we could find that the incidence of hypotonia in RF and MW workers mostly is 20-40%, and in the most recent ten years, the incidence of hypertonia is higher than hypotonia. It has been suggested that hypertonia increases with working age, and occurs in advanced stages of the disease. Glotova observed the dynamic alteration of blood pressure of microwave workers. She divided the observed persons into three groups according to their initial pressure. They all were near thirty years of age.

TABLE 3: Dynamic Alteration of BP in MW Workers

Group No.	Observed Time	Total	BP (mm Hg) 90-95	100	105-135	140-145	150-160
1	initial	17	8	9	0	0	0
	after 3-6 years		3	6	2	3	3
2	initial	17	0	0	17	0	0
	after 3-6 years		0	0	5	6	6
3	initial	9	0	0	0	8	1
	after 3-6 years		0	0	0	1	8

The microwave exposure effects on ECG showed changes in cardiac rate, minor downward displacement of the S-T segment, lowering of T deflection, and slight deviations from normal in excitability and conduction of cardiac-electric activity (Table 4).

TABLE 4: Changes in ECG (Incidence %)

Group No.	Deep Bradycardia 50/min	Tachycardia 100/min	ST-T lower male	ST-T lower female	P 0.1s	QRS 0.1s	High potential at left ventricle (male)
1	1.63	6.54	11.8	34.29	6.86	10.78	11.92
2	3.93	3.36	11.2	14.61	7.85	11.59	12.89
3	0.42	4.25	5.6	18.07	3.18	4.03	8.95

In order to observe the microwave exposure effects on vascular functional state, rheoencepalogram, rheogram of finger hemodynamics and oculi fundus were examined. There were no significant findings in the results.

The data mentioned above show that microwave action was characterized by autonomic vascular symptoms of a vagotonic character, expressed especially in hypotonia and bradycardia. Sadchikova and many Soviet authors [4,5,6] state that the asthenic syndrome in the initial stages included mainly a complex of asthenic symptoms dominated by autonomic vascular changes with a vagotonic tendency. In the advanced stages of the disease, the astheno-autonomic syndrome with vascular dysfunction of the hypertonic type was most frequent. At a certain stage of development of autonomic vascular disturbances, the hypothalamic syndrome (autonomic vascular form) appeared and was characterized by sudden crises, predominantly of a sympathico-adrenal character. In our investigations, the autonomic vascular symptoms of most persons maintained a vagotonic character, while they were observed over a period of five years. Nothing of such severity as to be described as hypothalamic syndrome was found. It seems that the nature and sensitivity of cardiovascular reactions to prolonged exposure depend, to a large extent, on the individual characteristics. Further study on clinical manifestations and its mechanism could be valuable, as some doctors in our country are now interested in using microwave in treatment for hypertension.

The hypotonia and bradycardia were also observed in RF workers in China, but the incidence was not so high as that in microwave workers.

3. Effects on peripheral blood

No characteristic changes in peripheral blood picture were found, only a slight leukopenia and thrombocytopenia occurring in the first group as compared to the others ($p<0.001$).

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Table 5 Incidence of Leukopenia and Thrombocytopenia

Group No.	Leukocyte (%) <5,000/mm^3	Leukocyte (%) >9,000/mm^3	Thrombocyte (%) <100,000
1	29.41	1.96	26.79
2	18.69	8.6	14.02
3	21.23	7.2	17.2

Diversified WBC responses are found in many reports. In general, slight or moderate leukopenia may be found in microwave workers working at high power densities. In a number of cases leukocytosis was encountered in the initial period of professional exposure. Absolute lymphocytosis may also be found in microwave workers.

4. Effects on eye

Several epidemiological surveys of lenticular effects of microwave workers have been performed. None of the surveys reported a statistically significant increase in the number of cataracts in personnel occupationally exposed to microwave radiation. The surveys were mostly concerned with minor lenticular defects. Some of the surveys indicated a statistically significant increase in lenticular defects in microwave workers. Zydecki [7] examined 3,000 persons divided equally into three groups. Group A comprised two subgroups. A_1 contained 542 individuals exposed directly to microwave radiation at power density of about 0.1 mW/cm^2 up to 6 mW/cm^2. Group A_2 comprised 458 individuals exposed to MW at about 0.01 mW/cm^2. Group B comprised 1,000 age-matched individuals not exposed to microwave, while Group C was made up of children and juveniles aged 5 to 17 years. The examination of the lens was made using a slit lamp after dilatation of the pupil. Lens translucency was assessed using a 5-grade scale:

1° No lens changes
2° Numerous small, multishaped opacities, which may be counted
3° Numerous small, multishaped opacities, which are difficult to count
4° As above, but with a tendency to increase in number or size on successive examinations
5° Any change impairing visual acuity

Statistically significant differences in the frequency of various grades of lens translucency exist between Group A and Groups B and C. Moreover the comparison between A_1 and A_2 also demonstrates significant differences (Table 6). The author indicated that long-term overexposure to low doses of microwaves may tend to accelerate the normal aging process of the lens.

Table 6 Percentage incidence in various lens translucency grades

Lens Tranclucency Grade	Group A			Group B	Group C
	A_1	A_2	A_1+A_2		
1	13.0	31.3	21.7	29.7	68.8
2	62.0	52.6	57.7	50.3	26.9
3	19.7	12.2	16.2	16.6	3.6
4	4.8	3.5	4.1	2.6	0.3
5	0.5	-	0.3	0.8	0.4

In our investigation, the lenticular transparency was examined in 227 microwave workers and 117 age-matched persons as control. No significant differences in incidence of lens opacities were found. The incidence of lens vacuole in the first group was higher than that in the control group ($p<0.025$). A few cases of cataracts or retina hemorrhage points were found in the microwave workers.

Table 7 Incidences of lens changes (%)

Group No.	Lens opacity	Lens vacuole
1	71.21	24.24
2	76.4	15.53
3	79.4	10.26

Tengroth and Aurell [8] reported an increased number of retinal lesions in 68 workers in a Swedish factory where microwave equipment was tested. The retinal lesions were characterized by their resemblance to chorioretinal scars after inflammatory reactions. No data on the intensity of the radiation were provided, but the authors considered that the maximum permissible exposure of 10 mW/cm^2 is too high. The problem should be further investigated.

5. Reproduction and Genetic Effects

Microwave radiation can induce sterility in humans when the incident power density is high enough. In recent years, microwave has been used for birth control in some hospitals in our country. In some workers occupationally exposed to RF or MW, the spermatogenesis or menstrual pattern was altered, and even impotence occurred. But the total number of cases are too few to conclude a cause/effect relationship.

RF and MW radiation are teratogenic to experimental animals exposed at specific times during gestation, but there is no evidence of such in humans. The use of microwave heating as diathermy to relieve the pain of uterine contractions during labor was reported from Belgium. It was said that the babies were born healthy. Nevertheless, extreme caution must be exercised. A few cases of multiple inborn defects in the offspring of women irradiated

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immediately before or during the early stages of pregnancy with shortwave diathermy have been reported by Coccorza Erdman et al.

Siglor et al suggest that mongolism occurs more frequently among the offspring of fathers professionally exposed to microwaves. However, an intensive follow-up study failed to confirm the association. In general, there seems to be no hazard under ordinary professional exposure conditions.

In the United States, a study [9] of American Embassy personnel in Moscow was reported. The purpose of the study was to compare the morbidity and mortality experience of U.S. Government employees at the Moscow Embassy during the period 1953 to 1976 with the experience of employees who had served in other selected, nonirradiated Eastern European embassies during the same period. The study population consisted of 1827 employees at the Moscow Embassy and over 3000 of their dependents and 2561 employees at the eight comparison posts and 5000 of their dependents. Comparative analyses were made of all symptoms, conditions, diseases, and causes of death according to the abstract of the medical records, response to the Health History Questionnaire, diseases reported on the Questionnaire, and acquisition of death certificates. No differential health risks associated with presumed exposure to microwave radiation were demonstrated. The maximum exposure levels measured at or near the windows of the upper central building ranged from 1 uW/cm^2 to 15 uW/cm^2. Another study [9] was reported of a three year investigation that was aimed at the determination of health risks from microwave radiation of U.S. Naval persons. A population of approximately 40,000 (half constituted the exposed group, and half the control group) were examined for mortality, morbidity, reproductive performance and health of children. The data did not show any differences between the two groups. It did not assign the exposure doses to any individuals in this study. Some of the observed persons were exposed to microwave in excess of the 10 mW/cm^2 limit. Accidental exposure was at estimated levels exceeding 100 mW/cm^2. Radiomen and radar operators were generally exposed to levels well below 1 mW/cm^2.

It may be summarized that there are great differences in the methods, contents and results of investigations for evaluating the health hazard of microwave radiation between different countries, causing great controversy. Additionally, the health hazard in microwave usually is not so serious and so certain as that in any other disease. Numerous questions concerning the clinical course and pathogenesis of certain lesions caused by RF and MW radiation have not been clearly elucidated up till now, and the symptoms usually are reversible, but the existence of health hazardous effects of RF and MW can not be denied. An investigation [6] of the patients suffering from microwave sickness reported by Sadechikova illustrates this. It showed that, despite repeated therapeutic

courses and temporary withdrawal from work with microwave sources, upon returning to previous work conditions symptoms increased in severity, particularly among patients with advanced stages of the disease. In such patients autonomic vascular disturbances dominated, crises of cerebral and coronary insufficiency progressed and development of ischaemic heart disease and hypertension was observed. Cessation of work involving irradiation frequently resulted in stabilization of the initial stage of illness (Table 8).

Table 8 Clinical course of microwave radiation during and after exposure

Clinical syndromes	Period of observation	No. of cases	Clinical course		
			Recovery	Stabilisation	Progression
Asthenic	A	25	-	13	11
	B	5	3	2	-
Astheno-autonomic with vascular dysfunction	A	47	-	-	47
	B	16	-	15	1
Hypothalamic (autonomic vascular form)	A	2	-	-	2
	B	6	-	5	1
Total		100	3	35	62

A: under MW exposure B: after cessation of exposure

This implies that those syndromes are not easy to recover, and it is important to lower exposure level and improve work conditions for protection from hazardous radiation.

Radiation conditions related to health hazard and standard promulgation in China

In order to set a reasonable safety standard of RF and MW radiation, conditions related to health hazard should be reviewed. Several exposure standards [10,11,12,13,14] in different countries are reported.

1. Radiation intensity

It might be considered that according to epidemiological data from exposure to microwave energy, long-term exposure at several mW/cm^2 may induce alteration not only in nervous and cardiovascular systems, but in the normal aging process of the lens and peripheral